T01D05 – Nomenclature

Name…….

We are going to write the names of covalent (or molecular) compounds. We are going to stick to binary compounds (composed of only two elements). If we try to name molecular compounds or three or more elements they do not following this nomenclature and will be discussed in Organic Chemistry (Topic 10)

Molecular (covalent) compounds are composed of two non-metals. We cannot use the periodic table to predict the oxidation state or valence of non-metals. If you look at your periodic table at the non-metals notice all of the oxidation states available. **Example—Nitrogen can be +-3,5,4,2—because of this I cannot choose one of them over another**.

Instead when I write the formulas or I name molecular compounds I have to do it another way. The process we use is as follows. The element (or ion) written first is named as it is for ionic compounds and the second element (or ion) will ALWAYS END IN **IDE**. For molecular compounds we will be using prefixes to tell someone how many are in a compound. Remember when naming ionic compounds we never use prefixes but for molecular compounds we will always use prefixes. The prefixes used are:

Prefix	Meaning	Prefix	Meaning
Mono	1	Di	2
Tri	3	Tetra	4
Penta	5	Hexa	6
Hepta	7	Octa	8
Nona	9	Deca	10

Formula	Name	Formula	Name
SF_2	sulfur difluoride	PCl_3	phosphorus trichloride
OCl	oxygen monochloride	$AsCl_5$	arsenic pentachloride

Mono is a prefix used but NEVER used for the first element. That is why we do not say monosulfur difluoride or monooxygen monochloride, etc.

Writing the formulas of or naming molecular is much easier than for ionic compounds. All I have to remember is to use (or remember) the correct prefix. There is no cross multiplying like in ionic compounds. We do not have to worry about the individual charges. Now I want you to try some. Be neat and write legibly. Again the first one done does not necessarily win. Inert gases can also form compounds so be careful. All of the following are molecular compounds. There are **NO** ionic compounds listed. **ALL work**.

Formula	Name	Formula	Name
SF_6			ClF
	oxygen dibromide	OF_2	
	xenon terafluoride		dinitrogen tetroxide
N_2O		NO_2	
NO		P_2O_5	
	dinitrogen trioxide		tetraphosphorus decoxide
$AsCl_5$		$SiCl_4$	
$SbCl_3$			carbon tetrachloride
	nitrogen monoxide	SiO_2	
NI_3		SO_2	
N_2O_5			carbon monoxide

Formula	Name	Formula	Name
	carbon dioxide		xenon tetraiodide
BrCl		PF_5	
KrO_4			sulfur hexaiodide
$AsCl_3$		Sb_2O_3	
	oxygen dichloride	SeO2	

IONIC NOMENCLATURE:

Ionic compounds are formed when a metal loses electrons, and a non-metal gains those electrons. Compounds are generally electrically neutral which means that the electrons lost by the metal are gained by the non-metal. No excess or deficiency or electrons can exist. There are several types of ionic compounds.

Type I: The first type called Type I consists of a metal that can have only one valence or oxidation number and a non-metal from the periodic table. The metals in Group IA(Li), IIA(Be), IIIA(B), and a few of the transition elements such as scandium, yttrium and silver fall into this category. When the metals lose electrons they are called **cations** and have charges of +1, +2 or +3. The non-metals will gain a set number of electrons those in Group 15 (nitrogen family) will gain three electrons to become -3; Group 16 (Oxygen family) will gain two electrons to become -2; Group 17 (Fluorine family) will gain one electron to become -1. The other numbers you see over their symbols (Groups 15,16 and 17) are because they can form a number of covalent or molecular compounds and polyatomic ions. Non-metals are given the general name **anions.** All of these are binary compounds.

Type I:

Write the formulas for the following binary ionic compounds.

Type I: Ionic	S	Cl	N	O	C^{4+}
Ba^{2+}	BaS barium sulfide	$BaCl_2$ barium chloride			
Sc^{2+}					
Na					
Al					
Mg					
Ag^{+}					Ag_4C silver carbide

These compounds are named by having the metal ion retain its original name, and the non-metal changing its ending to -ide. The first one above would be barium sulfide, and then barium chloride. Name the remaining ones underneath their formulas

Type II: Ionic compounds are those having a metal that has a variable valence, and one of the non-metals we used above. The elements with variable valences are generally in the transition group of elements along with lead and tin, and a few other elements. The formulas are done the same way as above but the naming is slightly different. In the name of the compound we must include the charge of the cation.

Type II: Ionic	**Br**	**P**	**S**	**O**	**Cl**
Fe^{2+}	$FeBr_2$ iron (II) bromide				
Co^{3+}	$CoBr_3$ cobalt (III) bromide				
Ni^{3+}					
Fe^{3+}					
Au^{3+}					
Pb^{4+}					

When naming these compounds I have to include the charge of the metal ion. For example, the first one above is called iron (II) bromide, the second iron (II) phosphide. Only roman numerals are used, and the number applies to the charge on the metal ion, and not how many cations or anions are in the compound. Write the name of the remaining compounds underneath their formulas.

There is an older way of naming these compounds that is still in existence. We will not be using it but it is still common, and in use. The lower valence or oxidation number of the metal will end in **ous** and the higher oxidation state will end in **ic**. The first one above would be called ferrous bromide instead of iron (II) bromide and the second one would be ferrous phosphide instead of iron (II) phosphide. Ferrous is used instead of iron because it is its older name from which its symbol is derived. Most of the transition series would be easier. Cobalt (II) would be cobaltous and cobalt (III) would be cobaltic, and so forth. We will stick the roman numeral method of naming these compounds which is the preferred method. The –ic and –ous will be used for naming acids though.

Type III: ionic compounds are those having have a metal ion (Type I or II), and a polyatomic ion (sometimes referred to as an oxyanion). Writing the formulas is just as above except that when multiple units of the polyatomic ion appear in the compound I have to include parenthesis around the ion.

Complete the following table of Type III ionic compounds

Type III: Ionic	**SO_4^{2-}**	**PO_4^{3-}**	**$S_2O_3^{2-}$**	**OH^-**	**CO_3^{2-}**
Ba	$BaSO_4$ barium sulfate				
Fe^{3+}	$Fe_2(SO_4)_3$ iron (III) sulfate				
Na					

Type III: Ionic	**SO_4^{2-}**	**PO_4^{3-}**	**$S_2O_3^{2-}$**	**OH^-**	**CO_3^{2-}**
Al					
Pb^{2+}					
Ag					

Naming these compounds is just you have done in the previous two exercises. The first one is called barium sulfate, and the second one is barium phosphate. Now name the remaining underneath their formulas. REMEMBER if the metal has a variable valence I must include a roman numeral in its name.

Commonly Used Polyatomic Ions

(1+) CATION	**(1-) ANION**	**(2-) ANION**	**(3-) ANION**
Ammonium NH_4^+	Chlorate ClO_3^-	Carbonate CO_3^{2-}	Phosphate PO_4^{3-}
	Chlorite ClO_2^-	Sulfate SO_4^{2-}	Phosphite PO_3^{3-}
	Hydroxide OH^-	Sulfite SO_3^{2-}	Citrate $C_6H_5O_7^{3-}$
	Nitrate NO_3^-	Hydrogen phosphate HPO_4^{2-}	Ferricyanide $Fe(CN)_6^{3-}$
	Nitrite NO_2^-	Oxalate $C_2O_4^{2-}$	Arsenate AsO_4^{3-}
	Acetate CH_3COO^- or $C_2H_3O_2^-$	Chromate CrO_4^{2-}	Borate BO_3^{3-}
	Cyanide CN^-	Dichromate $Cr_2O_7^{2-}$	
	Hydrogen bi-carbonate HCO_3^-	Thiosulfate $S_2O_3^{2-}$	
	Hydrogen bi-oxalate $HC_2O_4^-$	Molybdate MoO_4^{2-}	
	Hypochlorite ClO^-	Peroxydisulfate $S_2O_8^{2-}$	
	Hydrogen bi-sulfide HS^-	Silicate SiO_3^{2-}	
	Hydrogen bi-sulfate HSO_4^-	Tartrate $C_4H_4O_6^{2-}$	
	Hydrogen bi-sulfite HSO_3^-	Peroxidate O_2^{2-}	
	Dihydrogen bi-phosphate $H_2PO_4^-$		
	Permanganate MnO_4^-		
	Iodate IO_3^-		
	Bromate BrO_3^-		
	Thiocyanate SCN^-		
	Periodate IO_4^-		
	Perchlorate ClO_4^-		
	Perbromate BrO_4^-		

Type IV: Acid Nomenclature

The naming of acids is different from naming ionic or molecular compounds. Acids are molecular compounds that are dissolved in water. Essentially there are two different types of acids, one type is called binary acids and they consist of two elements: Hydrogen and any non-metal with the exception of oxygen, and oxyacids which consists of three or more elements: hydrogen and a polyatomic ion containing oxygen. Each has its own process for naming.

BINARY Acids: These are acids which contain the element Hydrogen and any other non-metal (except oxygen, that's water).

Again, when making a compound the positive ion (cation) and negative ion (anion) must equal zero. Remember these are molecular compounds. Hydrogen which is a +1 (and written first) will combine with non-metals of families 14(C), 15(N), 16(O) and 17(F) to form acids.

If hydrogen combines with sulfur then we have the compound H_2S, and when put into water solution we would call this hydrosulfuric acid. If H reacts with nitrogen we form H_3N, and if put into water solution we would have hydronitric acid.. Compounds have to have a neutral charge (pluses must equal minuses).

All binary acids always begin with the word *hydro*, and end with *ic*. The non-metal may or may not change its form. Sulfur stays sulfur (H_2S is hydrosulfuric acid) but nitrogen changes to nitr (H_3N is hydronitric acid). These take practice as does all of chemistry.

Write the formula for the following binary acids or name of the following binary acids, whichever is needed

Name	Formula	Name	Formula
hydrochloric acid	HCl	hydrofluoric acid	
hydrophosphoric acid		hydrocarbonic acid	
hydroselenic acid		hydroarsenic acid	
hydroiodic acid		hydrobromic acid	
	H_2Se		HI
	HCl		H_3As
	HF	hydronitric acid	H_3N

OXOACIDS:

Acids that contain hydrogen, oxygen, and another central element are called oxoacids. These formulas are written with the H first, followed by the 'other' central element, and then O as shown below:

HNO_3	nitric acid	(-ate to -ic)
H_2CO_3	carbonic acid	(-ate to -ic)
H_2SO_3	sulfurous acid	(-ate to -ous)
$HClO_2$	chlorous acid	(-ate to -ous)

Addition or Removal of H and O atoms from an Oxoanion

There are specific rules for the removal of H and O, and the resultant nomenclature, but we will learn simply based on our chart of given polyatomic ions. So long as an –ate turns to an –ic, and an –ite turns to an –ous, we should be ok! ☺

Write the correct formula for these oxyacids or write the name for these oxyacids, whichever is needed:

Name	Formula	Name	Formula
chloric acid		phosphorous acid	
iodic acid		carbonic acid	
nitric acid		nitrous acid	
perbromic acid		hypochlorous acid	
phosphoric acid		oxalic acid	
chlorous acid		tartaric acid	
	$HClO_2$		$HBrO_3$
	H_3PO_3		$HClO_4$
	$HC_2H_3O_2$		HCN
	$HMnO_4$		HClO
	$HClO_3$		H_2CrO_4

From the word equation 1st *write* the correct equation in symbol format and 2nd *balance* using the smallest integers possible

1. aluminum sulfate + calcium phosphate → aluminum phosphate + calcium sulfate

2. magnesium chloride + silver nitrate → magnesium nitrate + silver chloride

3. sodium chlorate →sodium chloride + oxygen gas

4. hydrogen gas + oxygen gas → water

5. zinc + cupric nitrate → zinc nitrate + copper

6. sodium iodide + chlorine gas → sodium chloride + iodine

7. copper (II) hydroxide → copper (II) oxide + water

8. calcium carbonate → calcium oxide + carbon dioxide

9. aluminum sulfate + barium chloride → aluminum chloride + barium sulfate

10. sulfuric acid + sodium hydroxide → sodium sulfate + water

11. hydrogen peroxide → water + oxygen gas

12.aluminum + ammonium perchlorate → aluminum oxide + aluminum chloride + nitrogen (II) oxide + water

13. ammonia + oxygen → nitrogen (II) oxide + water

14. sodium bicarbonate → sodium carbonate + carbon dioxide + water

15. potassium hydroxide + sulfuric acid → potassium sulfate + dihydrogen monoxide

16. acetic acid + sodium bicarbonate → sodium acetate + carbon dioxide + water

17. iron + hydrochloric acid → iron (II)chloride + hydrogen gas

18. lead (II) nitrate + hydrogen sulfide → lead (II) sulfide + nitric acid

19. antimony trichloride + hydrogen sulfide → hydrochloric acid + diantimony trisulfide